General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

SQT

INVESTIGATION OF SEVERAL ASPECTS OF LANDSAT-4 DATA QUALITY

ROBERT C. WRIGLEY, PRINCIPLE INVESTIGATOR

QUARTERLY PROGRESS REPORT #2

JUNE 20, 1983

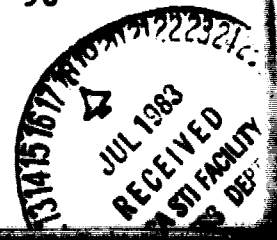
TM DATA RECEIVED: Detroit (4 bands), P-tape, 6250 bpi
Arkansas, P-tape, 6250 bpi
Washington, DC, P-tape and A-tape, 6250 bpi
Sacramento, CA, P-tape, 6250 bpi (via Bauer)

Four papers describing analytical techniques and results were written during the period for inclusion in various symposia. Copies of each paper are attached.

A paper by Likens and Wrigley entitled "Impact of Landsat MSS Sensor Differences on Change Detection Analysis" was submitted for inclusion in the Landsat-4 Early Results Symposium. By registering portions of scenes collected simultaneously by Landsat-4 MSS and either Landsat-2 or Landsat-3 and comparing the images pixel by pixel, Likens and Wrigley concluded there would be no insurmountable problems in change detection analysis using Landsat-4 MSS data in conjunction with data from the earlier sensors. We consider this test a sensitive indicatior of differences between the various sensors and we feel there are no important differences with one exception. The exception is the periodic noise we noticed in Landsat-4 MSS images which had an RMS value of approximately 2 DN. We feel such noise will damage results of multispectral analysis for land cover mapping and resource inventory although we did not conduct either analysis. We understand the cause of this problem is known and we further understand the same problem is known to exist with the Landsat-D' MSS instrument. In order that the civil remote sensing effort in the United States not be greatly damaged, we urge that the cause of the periodic noise in MSS data be corrected in the Landsat-D' MSS instrument before its launch.

Card et al. submitted a paper for the proceedings of the Landsat-4 Early Results Symposium entitled "Assessment of Band-to-Band Registration by the Block Correlation Method". Their analysis of the P-tape of the Arkansas scene showed bands within the same focal plane were very well registered except for the thermal band which was misregistered by approximately three 28.5 meter pixels in both directions. Between the cooled and uncooled focal planes, they measured misregistrations of 0.2 pixels across-scan and 0.5 pixels along-scan. Due to the large number of points involved and the consistency of the method, it is possible to derive tight confidence bounds for the registration errors. We consider these results to be definitive for the Arkansas scene with the possible exception of the thermal band results which were based on lower correlations and only 96 measurements.

(E83-10390) INVESTIGATION OF SEVERAL ASPECTS OF LANDSAT-4 DATA QUALITY Quarterly Progress Report (NASA) 5 p HC A02/MF A01
CSCL 05B
N83-32143
Unclas
G3/43 00390



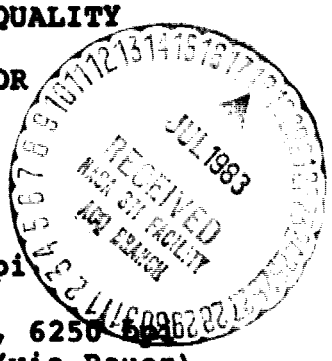
TM E85 10390 SPT

~~GR 170999~~

INVESTIGATION OF SEVERAL ASPECTS OF LANDSAT-4 DATA QUALITY

Made available under NASA sponsorship
In the interest of early and wide dissemination of Earth Resources Survey Program information and without liability for any use made thereof."

ROBERT C. WRIGLEY, PRINCIPLE INVESTIGATOR



QUARTERLY PROGRESS REPORT #2

JUNE 20, 1983

TM DATA RECEIVED: Detroit (4 bands), P-tape, 6250 bpi
Arkansas, P-tape, 6250 bpi
Washington, DC, P-tape and A-tape, 6250 bpi
Sacramento, CA, P-tape, 6250 bpi (via Bauer)

Four papers describing analytical techniques and results were written during the period for inclusion in various symposia. Copies of each paper are attached.

A paper by Likens and Wrigley entitled "Impact of Landsat MSS Sensor Differences on Change Detection Analysis" was submitted for inclusion in the Landsat-4 Early Results Symposium. By registering portions of scenes collected simultaneously by Landsat-4 MSS and either Landsat-2 or Landsat-3 and comparing the images pixel by pixel, Likens and Wrigley concluded there would be no insurmountable problems in change detection analysis using Landsat-4 MSS data in conjunction with data from the earlier sensors. We consider this test a sensitive indicatior of differences between the various sensors and we feel there are no important differences with one exception. The exception is the periodic noise we noticed in Landsat-4 MSS images which had an RMS value of approximately 2 DN. We feel such noise will damage results of multispectral analysis for land cover mapping and resource inventory although we did not conduct either analysis. We understand the cause of this problem is known and we further understand the same problem is known to exist with the Landsat-D' MSS instrument. In order that the civil remote sensing effort in the United States not be greatly damaged, we urge that the cause of the periodic noise in MSS data be corrected in the Landsat-D' MSS instrument before its launch.

Card et al. submitted a paper for the proceedings of the Landsat-4 Early Results Symposium entitled "Assessment of Band-to-Band Registration by the Block Correlation Method". Their analysis of the P-tape of the Arkansas scene showed bands within the same focal plane were very well registered except for the thermal band which was misregistered by approximately three 28.5 meter pixels in both directions. Between the cooled and uncooled focal planes, they measured misregistrations of 0.2 pixels across-scan and 0.5 pixels along-scan. Due to the large number of points involved and the consistency of the method, it is possible to derive tight confidence bounds for the registration errors. We consider these results to be definitive for the Arkansas scene with the possible exception of the thermal band results which were based on lower correlations and only 96 measurements.

Wrigley et al. submitted a paper entitled "Thematic Mapper Image Quality: Preliminary Results" to the proceedings of the IEEE International Geoscience and Remote Sensing Symposium. They edited the results of Card et al. by discarding some outliers and collected the definitive results in a single table which is reproduced here as Table 1. In addition, they analyzed the latest image available to them (the Sacramento scene of February 1, 1983) by the same methodology. Although TM bands 6 and 7 were not available for analysis (the computer center lost the tape temporarily), Wrigley et al. found a very high degree of consistency with the earlier results for bands 3 vs 1, 3 vs 4, and 3 vs 5 even though the number of correlation blocks retained for analysis after editing was reduced by a factor of three. (The reason for the reduction is not completely understood but is suspected to be related to the low light conditions at the time and/or the larger amount of cloud cover.) Their results are reproduced here as Table 2 which also includes some results from bands 6 and 7. They found that the confidence limits for registration errors overlapped for the Arkansas and Sacramento scenes. They felt this high degree of consistency for two scenes collected and processed six months apart spoke well for both the LAS processing system and our method of analysis. Wrigley et al. also suggested attention could be directed to the standard deviations of the registration errors to judge whether or not they will be within specification once any known mean registration errors are corrected. In most cases the standard deviation is smaller than the permitted error; this indicates the bands in question will be within the permitted error bounds 68% of the time or better. For band pairs between focal planes, the standard deviations approach or exceed the permitted error and indicate these combinations may not meet the specification even when the mean errors are removed. Recent results using the relocated tape show that bands 3 vs 7 follows the same patterns as described above for the mean shifts, confidence bounds and standard deviations. Although the along-scan results for bands 6 vs 7 also follow the same patterns as the Arkansas scene, the across-scan results are different. The difference may not be real because of the small number of correlation blocks retained for analysis and their low correlations, but the result is that the registration error across-scan is now close to zero.

Wrigley et al. also reported some very preliminary analysis of interdetector variations and periodic noise using band 1 from an A-tape of the Washington, DC scene of November 2, 1982. In addition to a peak at a spatial frequency of 5.33 pixels in the across-scan direction, a sub-harmonic which is not understood, Fourier analysis revealed a peak at 3.2 pixels in the along-scan direction which also had across-scan components. The latter peaks are interpreted to be periodic noise. The use of the A-tape has been hampered by the variable offsets between scan sweeps; our attempts to correct them using information in the HAAT file resulted in an over-correction.

Schowengerdt prepared a paper for inclusion in the proceedings of the Landsat-4 Early Results Symposium. Entitled "MTF Analysis of Landsat-4 Thematic Mapper", the paper describes the various techniques he intends to use as the data becomes available. Even more recently, Schowengerdt's progress report describes some work in progress on the Washington, DC A-tape. He windowed out three 512x512 pixel subsections and conducted Fourier analysis to obtain the power spectrum of lines in 1) the forward scan mode and 2) the back-scan mode. Although the results were a bit noisy, Schowengerdt concluded there was little difference in the MTF between the two modes. His Progress Report is attached for a more complete description of his activities. We are currently sending Schowengerdt copies of the P-tape of the Washington, DC scene for comparison to the A-tape to determine if any degradation of the MTF occurs in ground processing. We are also sending him copies of the San Francisco scene of December 31, 1982 which we obtained through the courtesy of D. Mouat of our Branch at Ames. Schowengerdt will examine the scene to select flightlines for simultaneous underflights with the NS001 Thematic Mapper Simulator if and when such flights may be possible.

Table 1

Summary statistics for band to band registration of Thematic Mapper band combinations for the Arkansas scene, August 22, 1982. All correlation blocks with the correlation coefficient <0.6 were discarded (0.3 for 6 vs 7). The unit of misregistration (shift) is pixels.

TM Bands	Shift Direction	Number of Blocks	Mean Shift	Std. Dev.	95% Conf. Int. for Mean Shift
3 vs 1	Across-scan	256	-.04	.06	-.05,-.03
	Along-scan	256	-.03	.06	-.04,-.02
3 vs 4	Across-scan	40	.01	.16	.00, .02
	Along-scan	40	.01	.16	.00, .02
3 vs 5	Across-scan	215	.25	.25	.22, .28
	Along-scan	215	.49	.25	.46, .52
3 vs 7	Across-scan	264	.16	.20	.14, .18
	Along-scan	264	.49	.18	.47, .51
7 vs 5	Across-scan	280	.06	.09	.05, .07
	Along-scan	280	-.01	.07	-.02, .00
6 vs 7	Across-scan	96	-3.2	3.1	-3.8,-2.5
	Along-scan	96	-3.0	2.7	-3.5,-2.4

Table 2

Summary statistics for band to band registration of Thematic Mapper band combinations for the Sacramento scene, February 1, 1983. All correlation blocks with the correlation coefficient <0.6 were discarded (0.3 for 6 vs 7). The unit of misregistration is pixels.

TM Bands	Shift Direction	Number of Blocks	Mean Shift	Std. Dev.	95% Conf. Int. for Mean Shift
3 vs 1	Across-scan	87	-.05	.09	-.06,-.04
	Along-scan	87	-.04	.08	-.05,-.03
3 vs 4	Across-scan	44	.02	.19	-.01, .05
	Along-scan	44	.01	.17	-.02, .04
3 vs 5	Across-scan	68	.33	.32	.27, .39
	Along-scan	68	.57	.32	.51, .63
3 vs 7	Across-scan	63	.20	.21	.15, .26
	Along-scan	63	.58	.27	.51, .64
6 vs 7	Across-scan	24	.3	1.6	-.4, .9
	Along-scan	24	-2.8	2.2	-3.7,-1.9

PUBLICATIONS

Card, D. H., R. C. Wrigley, F. C. Mertz and J. R. Hall (1983). "Assessment of Band-to-Band Registration by the Block Correlation Method". In Proceedings of the Landsat-4 Early Results Symposium, NASA/Goddard Space Flight Center, Greenbelt, MD, Feb. 21-24, 1983.

Likens, W. C. and R. C. Wrigley (1983). "Impact of Landsat MSS Sensor Differences on Change Detection Analysis". In Proceedings of the Landsat-4 Early Results Symposium, NASA/Goddard Space Flight Center, Greenbelt, MD, Feb. 21-24, 1983.

Schowengerdt, R. A. (1983). "MTF Analysis of Landsat-4 Thematic Mapper". In Proceedings of the Landsat-4 Early Results Symposium, NASA/Goddard Space Flight Center, Greenbelt, MD, Feb. 21-24, 1983.

Wrigley, R. C., D. H. Card, C. A. Hlavka, W. C. Likens, F. C. Mertz and J. R. Hall (1983). "Thematic Mapper Image Quality: Preliminary Results". In Proceedings of the IEEE International Geoscience and Remote Sensing Symposium, San Francisco, CA, Aug. 31-Sept. 2, 1983.